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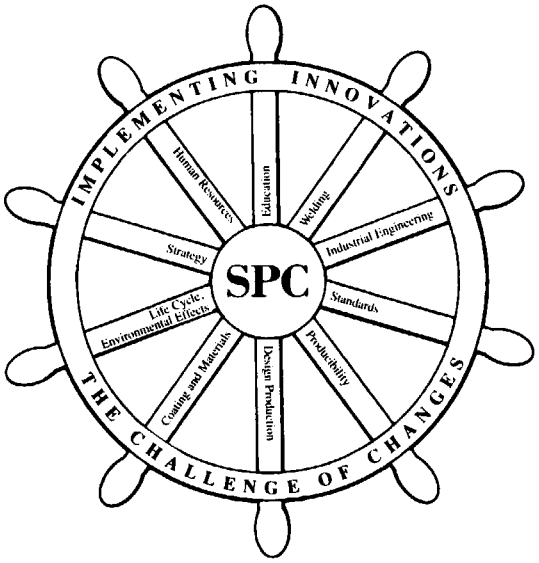

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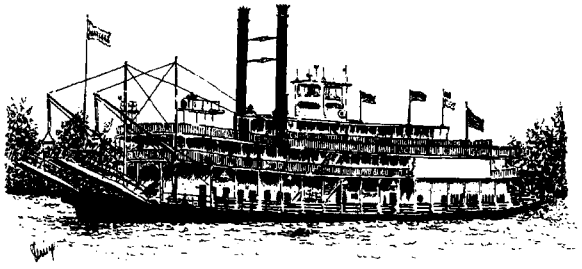

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601 PAVONIA AVENUE, JERSEY CITY, NJ 07306

Paper presented at the NSRP 1992 Ship Production Symposium, New Orleans Hyatt Regency, New Orleans, Louisiana, September 2-4, 1992

The Evolution of Cost/Schedule Control (Direct Labor) in Naval Shipyards

No. 8B-2

Scott N. Gessis, Visitor, Naval Sea Systems Command

ABSTRACT

The evolution of a Cost/Schedule Control System (C/SCS), for direct labor, in naval shipyards can be traced from the cost/schedule control concept used in the Air Force in the 1960s, as an initiative toward more reliable data. Subsequent C/SCS programs were initiated across the Department of Defense (DoD) in the late 1960s and early 1970s. As private shipyards came under what is known as Cost/Schedule Control System Criteria (C/SCSC), and its validation requirements, the issue of C/SCS in naval shipyards rose to the surface.

In 1984, the Naval Sea Systems Command (NAVSEA) issued a directive which called for C/SCS implementation in naval shipyards. Expanded use and standardization has followed. This paper reviews basic C/SCS principles, how naval shipyards have used C/SCS in improving performance, and how it has been standardized while still retaining a degree of flexibility.

NOMENCLATURE

ACWP. Actual Cost for Work Performed.

BCWP. Budgeted Cost for Work Performed.

BCWP. Budgeted Cost for Work Scheduled.

CPI. Cost Performance Index.

C/SCS. Cost/Schedule Control System.

C/SCSC. Cost/Schedule Control System Criteria.

CV. Cost Variance.

DoD. Department of Defense.

FBS. Financial Breakdown Structure.

NAVSEA. Naval Sea Systems Command.

OBS. Organizational Breakdown Structure.

PEC. Predicted End Cost.

SPI. Schedule Performance Index.

SV. Schedule Variance.

WBS. Work Breakdown Structure.

INTRODUCTION

In the 1960s various organizations recognized the need for improved performance on projects while they were taking place instead of trying to apply "lessons learned" after the fact. It became clear that if one expended 50 percent of the planned total budget, one wasn't necessarily half done.

Cost/schedule control is not another system but a set of criteria, or principles if you will, that an organization uses in undertaking major defense programs (1). Cost and schedule variances can be

traced to the source by analyzing management exception reports and graphics, which display performance data. C/SCS provides feedforward control as opposed to feedback control. Feedforward control attempts to identify future deviations early enough so action can be taken to avoid problems as a result of those deviations (2). Through trend analysis and review of C/SCS information, the need to take corrective action can be identified. Without corrective action, the greatest C/SCS system in the world is meaningless.

In the 1970s private shipyards came under DoD Instruction 7000.2 for new construction contracts. The intention of the instruction is to outline requirements of C/SCSC for selected acquisitions (3). Previously, contractors' reporting systems were not effective regarding progress assessment. DoD Instruction 7000.2 outlined C/SCS criteria in a Joint Implementation Guide (4). The JIG outlines 35 criteria in five major areas: Organization, Planning & Budgeting, Accounting, Analysis, and Revisions and Access to Data.

In 1984, NAVSEA issued NAVSEA Instruction (NAVSEAINST) 7000.13, directing implementation of C/SCS in the naval shipyards. C/SCS was customized within the naval shipyard community so that performance could be maximized via robust management using C/SCS principles and not focusing simply on meeting a reporting requirement.

COST/SCHEDULE CONTROL PRINCIPLES & CRITERIA

NAVSEAINST 7000.13 outlined ten basic principles for cost/schedule control,

1. The system will be based *on* integrity. Actual cost and schedule progress data will be accurately collected and accumulated to report actual performance.
2. A hierarchical work breakdown structure consistent with specified scheduling requirements will be used to define work scope and subdivide the work into logical tasks.
3. The highest level of the cost hierarchy will be the project budget. The aggregate total of the lower level budgets will be traceable to, and will not exceed, the project budget.
4. The project work scope will be broken down into manageable and relatively small work task elements to facilitate the productive effort. Appropriate shipyard line managers should be involved in determining how work is broken down into work task elements.
5. Actual cost data and actual schedule performance data will be collected at the work task element level.
6. Cost performance will be measured by comparing actual costs for work performed to planned costs (e.g., budgeted or estimated costs) at the work task element level and at appropriate higher levels.
7. Schedule performance will be measured by comparing actual progress to planned progress at the work task element level and at appropriate higher levels.
8. Schedule performance and manning levels should continue to be planned and monitored below the work task element

level where required by the separate scheduling directives.

9. Deviations of actual performance from planned performance will be resolved by the responsible line manager.

10. A revised Predicted End Cost (PEC) or Schedule will be developed whenever significant deviations from planned performance occur

These ten principles were translated into finer details that could be measured in some manner. The details became embodied in 15 C/SCS criteria for the naval shipyards, which follow.

1. Accurate Charging. A specific level of accuracy is required; a formal policy is published; supervisors are held accountable for correct charging; an internal review process is operative.

2. Phvsical Progress Assessment. Progress is updated weekly for line items charged including support codes; physical is collected at or below the Key Operation (Key Op) (000) level; independent assessment procedures are implemented at Key Op level; Key Ops are closed in a timely manner. NOTE: Key Ops are basic work tasks.

3. Hierarchical Work Breakdown Structure. Work breakdown is consistent with NAVSEA scheduling directives; Key Ops for all direct labor, except general production services and non-production support, must be structured with clearly defined schedule and budget, and support only one Milestone (next higher level event); general production services and non-production Key Ops are sized and time-chased for practical manageability; functional management responsibility is established for each level of the WBS; Technical Work Documents (TWDs) are structured consistent with the WBS.

4. Hierarchical Financial Breakdown Structure. The total project budget is the sum of discrete parts which aggregate hierarchically from the Key Op or below.

5. Line Management Acceptance of the Work Breakdown Structure. A mechanism is in place for feedback from line managers and for participation in WBS development; there must be demonstrated use; there is general acceptance of the WBS.

6. Line Management Acceptance of Budgets. The responsible manager is aware of his/her budget; accountability is established; a feedback mechanism for line managers is in place.

7. cost Performance Data Aggregation, Cost data is identified at or below the Key Op level; cost data and cost performance data are aggregated to all levels of the FBS, OBS and WBS; cost performance data is displayed to

supervisors at appropriate levels of accountability.

8. **Schedule Performance Data Aggregation.** Schedule data is identified at or below the Key Op level; schedule data (BCWS) and schedule performance data are aggregated to all levels of the OBS and WBS; schedule performance data is displayed to supervisors at appropriate levels of accountability.

9. **Performance Measurement Baselines.** The BCWS is used as the Performance Measurement Baseline (PMB).

10. **Resolution of Performance Variances.** Performance data is used to ascertain status and identify reasons for significant variances; corrective actions are taken.

11. **Cost and Schedule ections.** Whenever there are significant deviations, C/SCS performance data is used to assess the need to revise Project Schedules and PECs

12. **Internal Reports.** Cost and schedule data is grouped and reported for all levels of OBS and WBS; cost data and cost performance data is aggregated and reported for appropriate levels of FBS; cost and schedule performance data is reported and displayed at appropriate levels of accountability; applicable reports are distributed at all appropriate levels for use in performance analysis.

13. **Graphics.** C/SCS performance data is graphically displayed for appropriate levels of the OBS and WBS.

14. **Training.** Lesson plans are established; classes are held; there is a continuing education program. Training is effective based on interviews and test records.

15. **Directives.** A C/SCS directive is issued and all criteria are addressed (6).

C/SCS USE

Once the need for C/SCS was established, a directive issued, criteria laid out, and the "system'' implemented, the next, important task was application of C/SCS principles in the execution of naval combatant overhauls. When the naval shipyards had fully implemented C/SCS by early 1988, the emphasis shifted from framework implementation to comprehensive use of the "system" and resolution of any associated problems. Daily management of shipyard operations using C/SCS was more important than just reporting performance. Reports are not the be-all and end-all of shipyard operations. Use of C/SCS tools in monitoring status, and then taking action, is the crux of the matter.

The basic C/SCS tool, in graphical form, is the set of curves depicting ACWP, BCWP and BCWS. See figure 1. ACWP represents actual expenditures through "time now." BCWP represents actual physical progress, or earned value, through "time now." BCWS represents the scheduled load of work over the projected length of the project.

The development of the BCWS as the baseline is shown in figure 2. Using the management-
-by-exception technique, a Group Superintendent can view his/her group graphs and reports and trace a problem to its source. Figure 3 shows a graph depicting C/SCS information for a Structural Group. Ideally, BCWP, or physical progress, would be at or above BCWS, the baseline, and at or above ACWP, actual cost. But there is both a negative Schedule Variance (SV) and Cost Variance (CV). The BCWP line is below the BCWS and ACWP lines. So the Group Superintendent would go to the next level. Figures 4, 5 and 6 show performance for the various Shops within the Group. Shop 17's C/SCS performance in figure 5 immediately catches the eye. There is a definite gap between BCWP and the BCWS and ACWP lines. One would then check Shop 17's graphs for the two major areas as in fiqures 7 and 8. Obviously the problem lies in the second-area, depicted in figure 8. Figures 9 and 10 further focus on Shop 17, area 2, by displaying performance of work centers. Figure 10 shows large negative variances in Work Center 20 for both cost and schedule. Now one may review a detailed report to key in on the particular line items that are causing a problem.

Various "growing pains" were noted with C/SCS implementation and use. A sample of the problems many of the naval shipyards had is outlined below:

-time and attendance data input too early for accuracy;
-progress not reported on small tasks (e.g., less than 40 manhours);
-some overlapping of events (i.e., work tasks associated with more than one upper level event);
-many Key Ops/work tasks too long in duration and/or too large in size, making accurate progress assessment and consistent work breakdown difficult;
-lack of adequate feedback from line managers in the work breakdown and/or budgets;
-PEC and/or Schedule not revised based upon C/SCS information or matched with actual costs & schedule, and
-most local C/SCS instructions failed to address all criteria.

Since 1988, naval shipyards have advanced on the learning curve and have demonstrated more intensive use of cost/schedule control principles and criteria. All of them have instituted regular C/SCS briefings in monitoring status of availabilities in progress.

MEASURABILITY & EFFECTIVENESS

RADM Roger Horne, a former Deputy Director of NAVSEA's Industrial and Facility Management Directorate, summarized the cornerstones of an effective C/SCS "system"' as three things: quality estimates, accurate physical progress assessment, and accurate labor charging. If the estimate base is not accurate, then there will be many deviations of performance. Physical progress assessment inserts reality into the equation as opposed to merely calculating progress based on expenditures. And if charges are not accurate, then one does not know how much a task really costs. Without accurate information it becomes a case of "GIGO" (garbage in, garbage out).

The shipyards have tried to develop a consistent and accurate estimate base via engineered and technical standards, and, for submarines, Class Estimate Standards (CES). Standards must be reviewed periodically because they can deteriorate over time due to procedural changes, new regulations

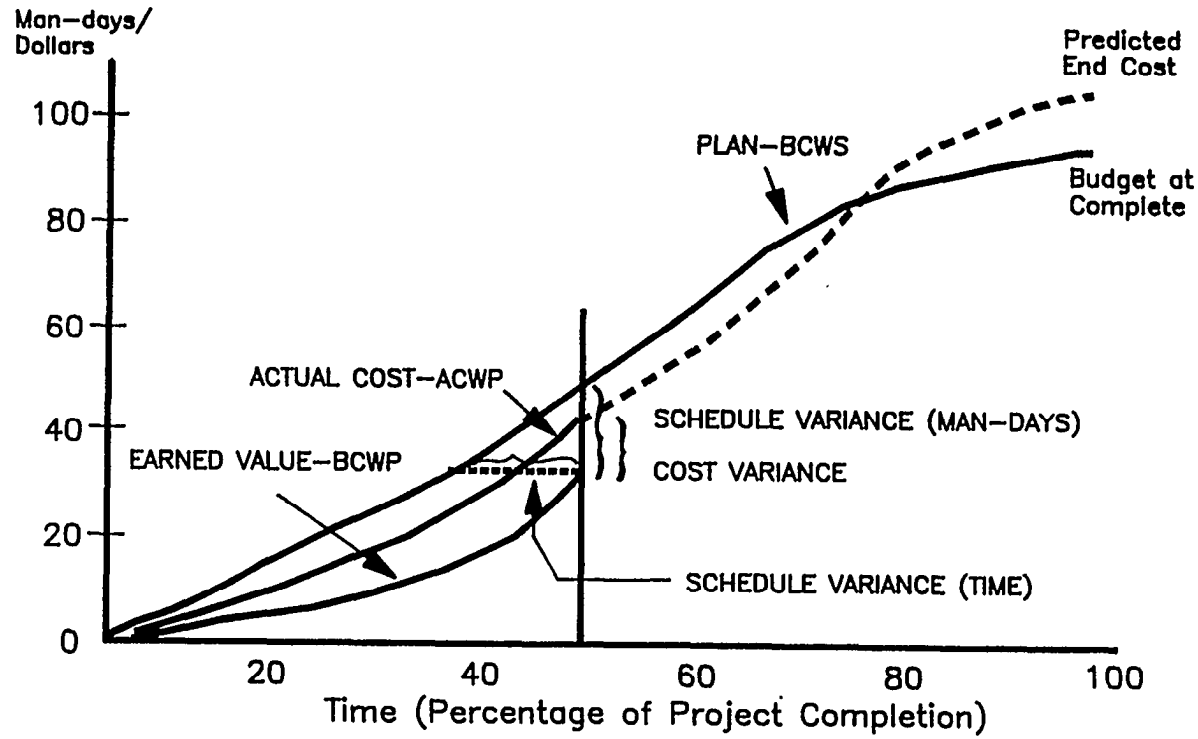

Figure 1 Project Cost and Schedule Performance

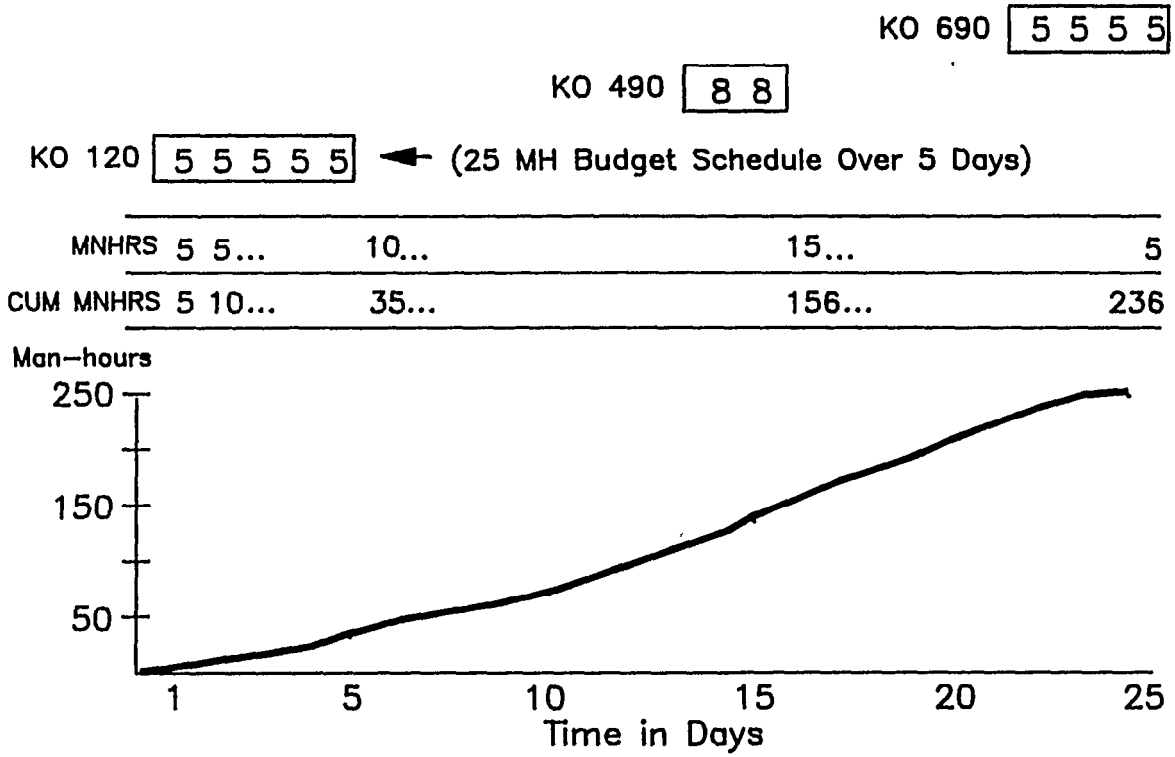

Figure 2 Building a Plan (BCWS)

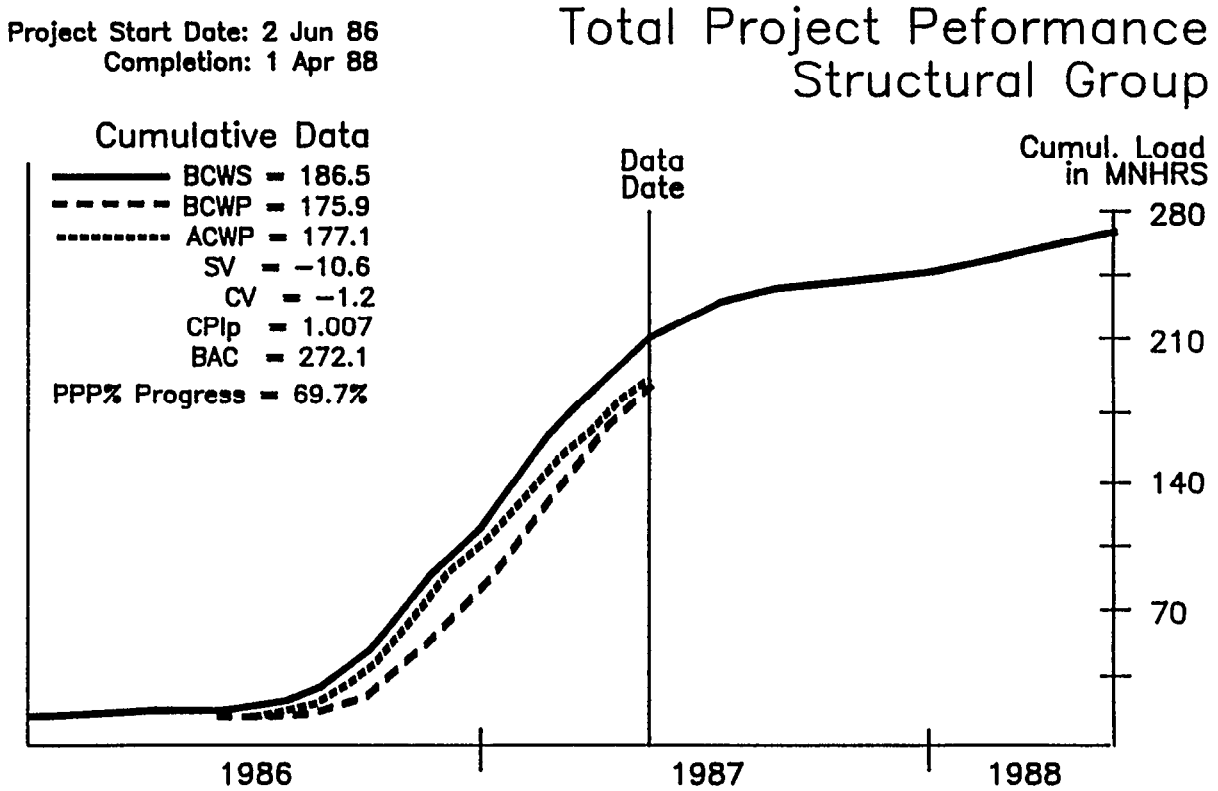

Figure 3 Variance Analysis/Graphics

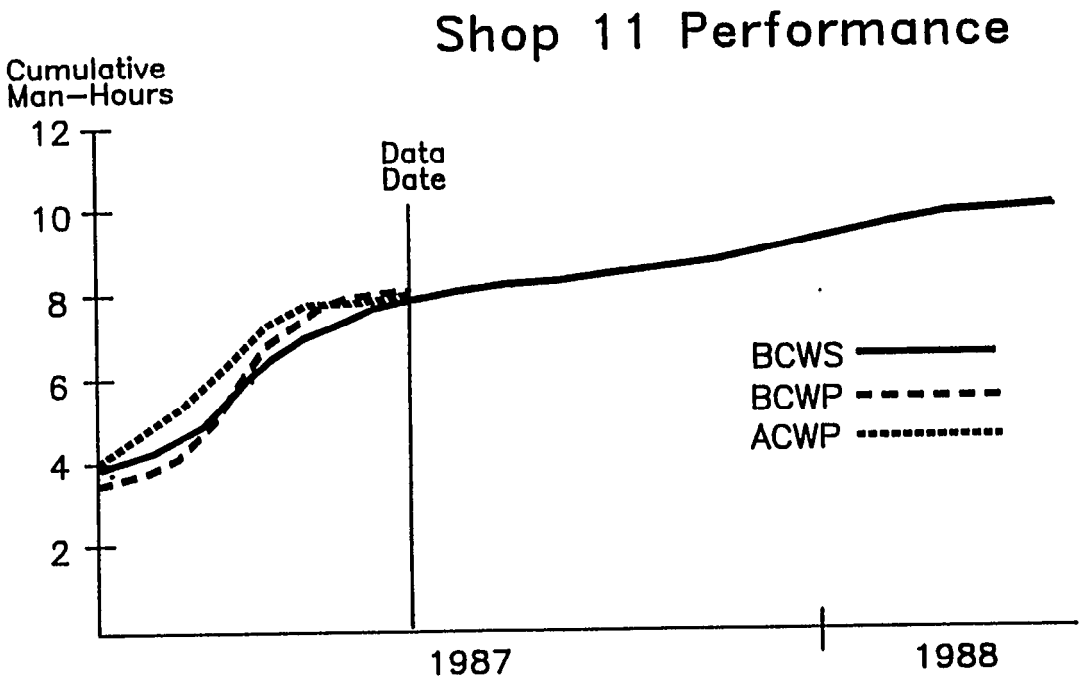

Figure 4 Variance Analysis/Graphics

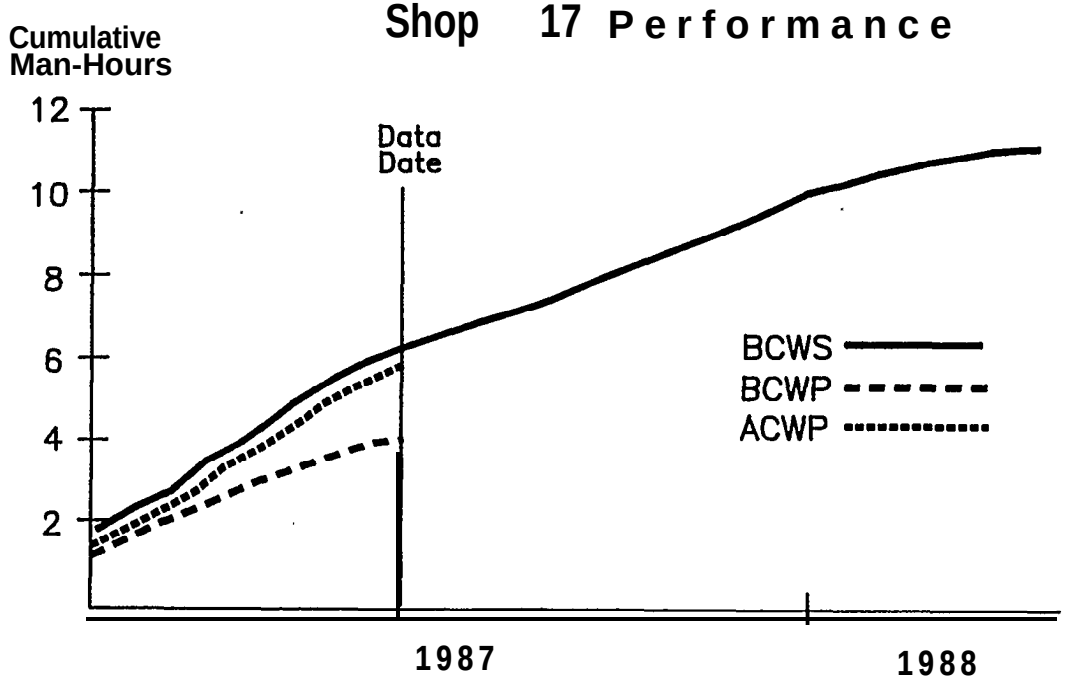

Figure 5 Variance Analysis/Graphics

(C/SCS Performance Graphics Indicate Poor Performance Trands in Shop 17)

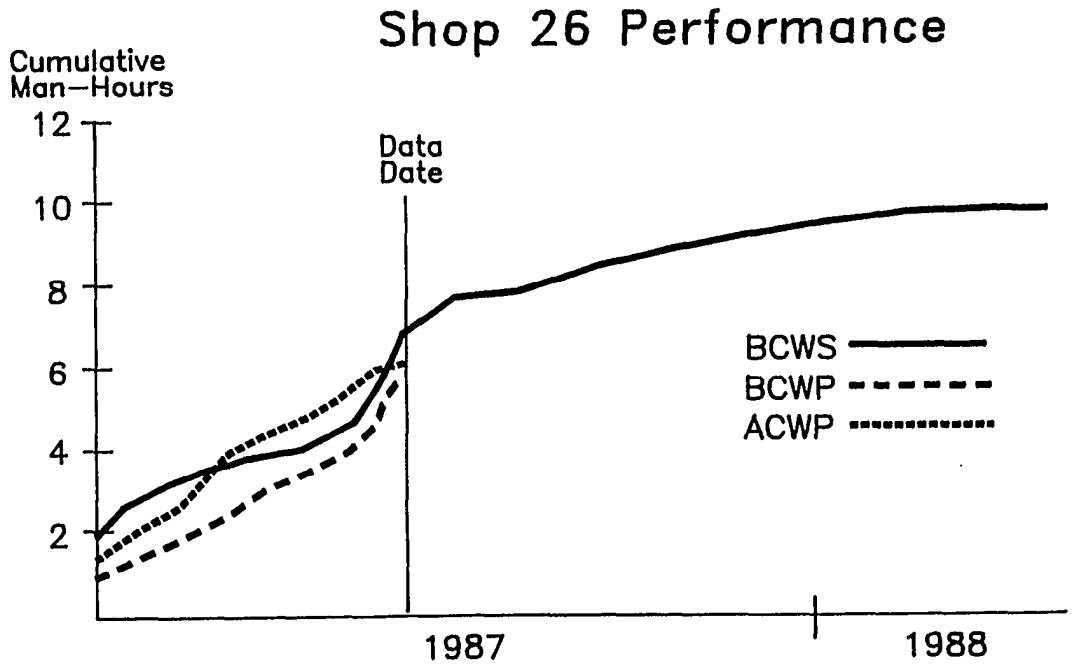

Figure 6 Variance Analysis/Graphics

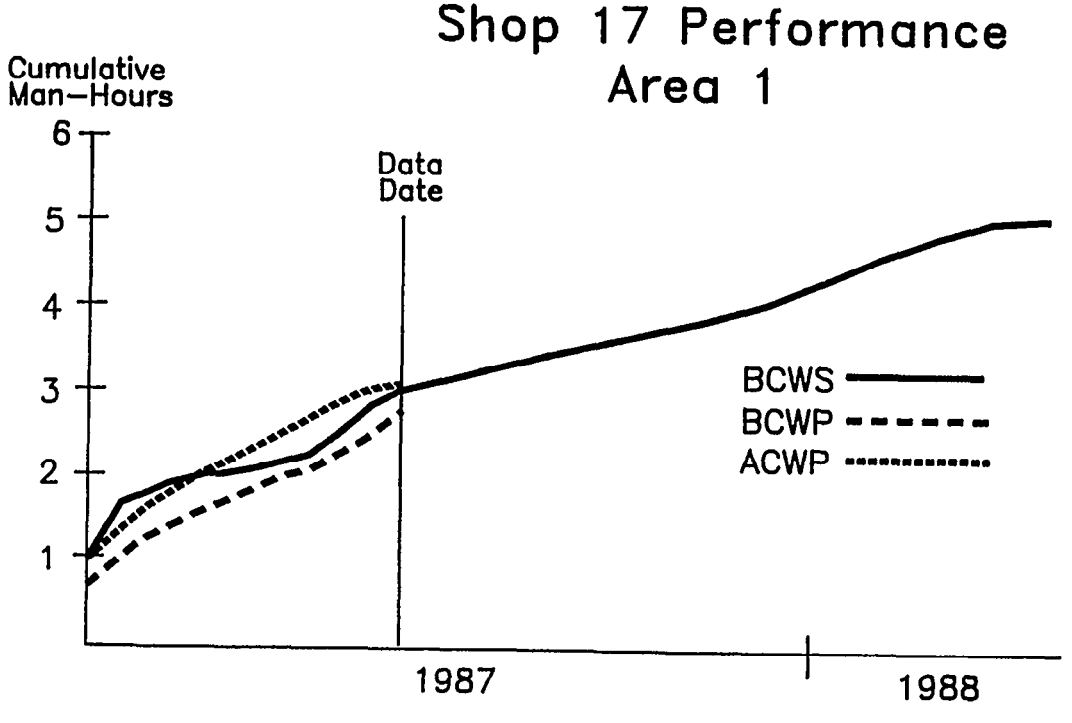

Figure 7 Variance Analysis/Graphics

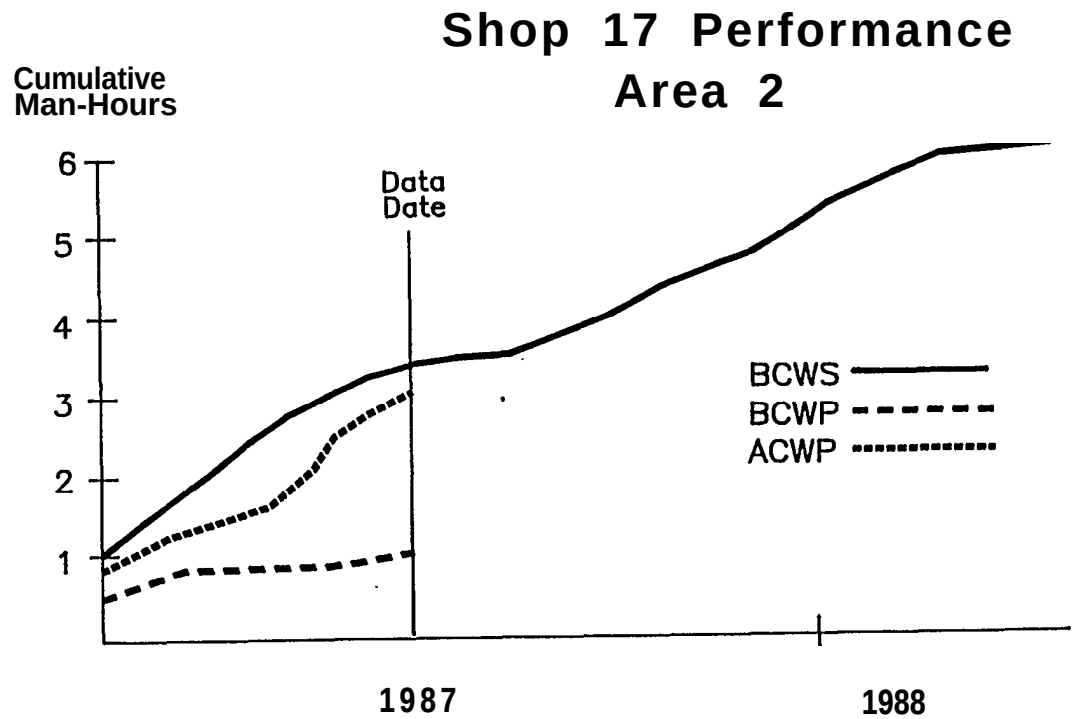

Figure 8 Variance Analysis/Graphics

(C/SCS Performance Graphics Can Trace Schedule and Cost Variances to Source for Corrective Action/Resolution

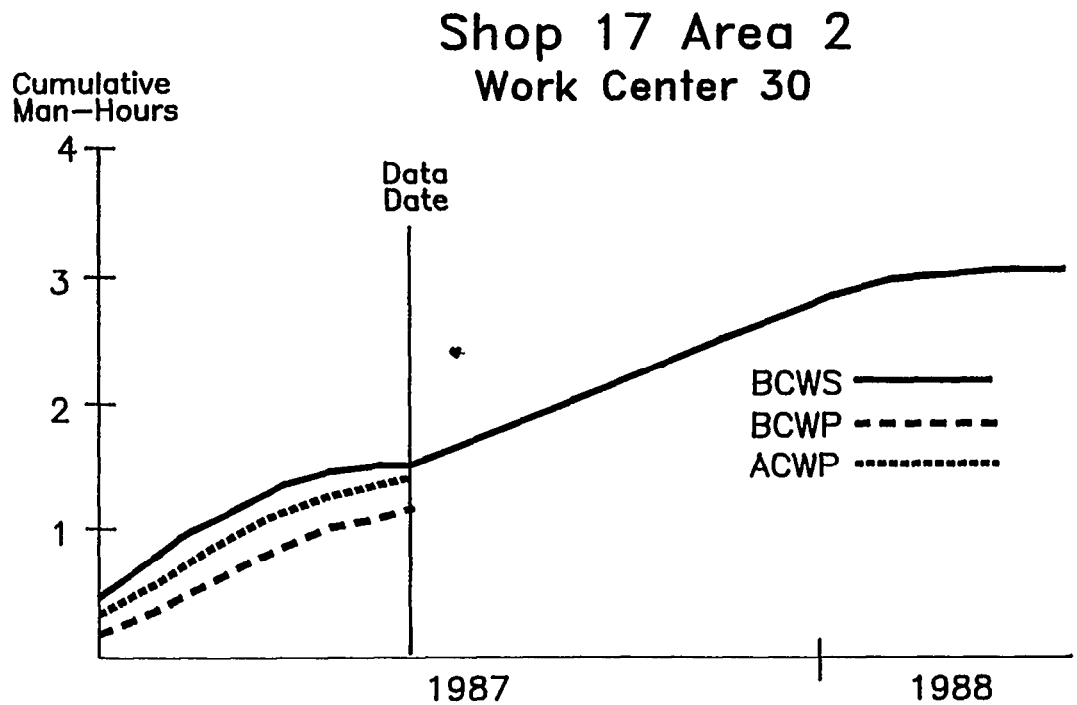

Figure 9 Variance Analysis/Graphics

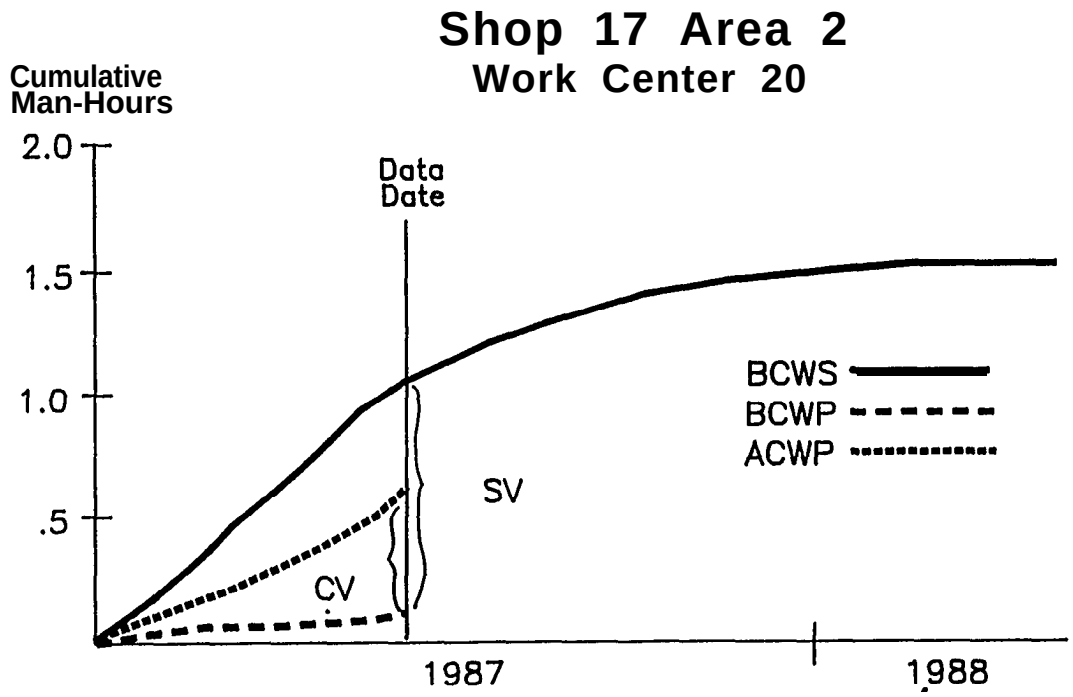

Figure 10 Variance Analysis/Graphics

(Utilization of C/SCS Performance Charts through the WBS and OBS, provide increased visibility and traceability to source of poor performance to enable rapid resolution)

and productivity improvements (7).

Physical progress assessment can seem subjective at times, such as estimating what percentage of a compartment is painted. But more often than not assessments can be objectively performed fairly well. Physical progress accuracy has improved greatly due to smaller work packages, independent assessment by other parties and through training in actual assessment procedures. Sometimes it's simply a component count to capture the correct progress. In cases where different size or type of components are in the same task, shipyard personnel have worked to analyze the situation so that certain "pieces" of a job equate to a certain percentage. In the service area, progress is captured based on a time-phase methodology. For example, rigging services may be broken down by pre-drydock phase, in dock, post-drydock. Each phase, or portion of a phase, equates to a certain level of progress.

Accurate labor charging requires use of methods such as smaller work packages, proper work sequencing and control of Job Order/Key Ops (tasks). There also must be proper charging and no "balancing of the books" where a foreman might use manhours on a job that performs well, or has not started, on a job that has reached its limit (estimated manhours for the entire task).

The evolution of progress in effectively using C/SCS Can be described by the chronological account of validation reviews of a particular shipyard. The author participated in most of the reviews. In 1986, C/SCS was in its infancy at the shipyards. This was reflected by review teams' observations. Many Key Ops/tasks were too long and crossed Milestones (next upper level event). Accurate charging was a formal policy only. There were major problems reporting BCWP and ACWP due to the inability to aggregate data through the various hierarchies. By 1988, tremendous progress had been made. Accurate charging was at the 90% range.

Independent assessment of physical progress had been instituted. The WBS had been restructured so that lower level tasks aggregated up through the higher level events without crossing boundaries. The number of Key Ops/tasks had increased from about 5,000 to about 11,000. While this required a lot of effort on the Planning Departments, dividends were paid on the other end. Accurate charging was achieved much easier, progress assessment was more accurate, etc.

The effectiveness of C/SCS in naval shipyards can be <u>somewhat</u> gauged by reviewing some performance trends. Overhaul and repair of modern warships is very complex, and many factors come into play. At Long Beach Naval Shipyard, a particular destroyer availability had the best performance for that class of ship to date. In the late 1980s the shipyard had won several "bid ships" in competition with other shipyards, with the shipyard firmly believing that implementation of C/SCS drove better planning and discipline in the system. More recently, cost and schedule performance improvement has been documented for a string of Depot Modernization Period (DMP) availabilities. A DMP is an SSN depot availability for installation of high priority warfare alterations, maintenance necessary to ensure unrestricted operations to design test depth. It is designed to increase SSN fleet operational-availability (8). While it is

likely is that a combination of a sense of purpose, continuous improvement/TQM and C/SCS has led to improvements, it was C/SCS that first helped institute more effective planning, objective status assessment, ability to trace problems to their source and early detection of problems than otherwise might occur.

STANDARDIZATION

Since NAVSEA, and SEA 07 in this particular case, is a corporation in every sense of the dictionary's meaning, corporate information requires a certain level of standardization regarding policies, procedures, and the like. Also, as many people in the corporation may transfer or rotate among the various shipyards (e.g., military officers, detailed personnel), it behooves the local sites to have some degree of commonality. The trick becomes how detailed to get regarding standardization. Should Darwin's theory of variation hold among the shipyards? That is, should each shipyard interpret the broad principles and criteria as they see 'fit? This is subject to debate, but the record shows an increase in standardization as C/SCS evolved from those first principles outlined in NAVSEAINST 7000.13.

In 1984 the principles and basic directive for implementation were issued. Subsequently 15 C/SCS criteria became the benchmark for validation of a shipyard's "system." In May of 1990, NAVSEA conducted a survey of C/SCS practices in the naval shipyards. The surveys were summarized in June of 1990 and discussions led to a change *in* the criteria. The criteria were further standardized to be used in the day-to-day operations and as a guide in future compliance reviews. Compliance reviews of the shipyards is an ongoing check of demonstrated use of c/scs. Highlights of the changes follow:

-designated charging accuracy of 95% to be achieved; -manhours used as a basis for accurate charging vice incidents;
-statistically valid sampling to confirm independent progress assessment;
-emphasized product-orientation above event-phasing or time-phasing for service type Key Ops/tasks;
-standardization of Schedule Performance Index/Cost Performance Index (SPI/CPI);
-designation of how BCWS (performance measurement baseline) is to be revised;
-enforce the discipline of rescheduling once C/SCS information makes it apparent that the current schedule cannot be executed.

Actions toward further standardization are objective, common-sense changes. The changes are good in that information Headquarters receives, and detailed or transferred personnel use, will be more consistent. The naval shipyard community uses standard, corporate criteria which facilitates report analysis, training, etc.

SUMMARY

C/SCS has been implemented in all the naval shipyards. The C/SCS concept is based on earned *value,* or physical progress assessment, as well as quality estimates and accurate charging. It is a feedforward *system* as opposed to an after-the-fact feedback concept. This allows early detection of problems and the ability to take corrective action while there is still time. c/scs information will not, by itself, improve performance. It does provide a valuable tool in monitoring trends and status.

Standardization of the cost/schedule control system has evolved within the naval shipyards since 1984 via basic principles, designated criteria and changes to standardized procedures. Further changes are being contemplated based on lessons learned through the implementation and demonstrated use over the last several years. c/scs has proven to help improve performance through early detection of variances and the synergy derived from participation of all levels of the shipyard in developing and using a consistent, well-planned process.

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